# OMNIS

## Observatory for Multiflavor NeutrInos from Supernovae

### A Proposed Facility

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# OMNIS Overview

Observation of Neutrinos from Galactic Supernovae

– Expected Number of Supernovae: ~3-6 per century

OMNIS

- Detection of $\nu_{\mu}, \nu_{\tau}, \nu_e$ + antineutrinos
- Identification of $\nu_e$
- Sensitive to different type of neutrino than Super-K
  - OMNIS: $\nu_e$
  - Super-K: $\nu_e$–bar

– Planned Lifetime of the Experiment: ~ 50 years

– Locations: WIPP (and possibly NUSL)

– Number of neutrino events from one Supernova
~2,500 from Galactic Center (8kpc); ~400 from far side of the Milky Way

# OMNIS Astrophysics

- Check the Standard Model of core collapse
  - What is the time evolution of the neutrino flux?
  - Measure the neutrino energy distributions
    - as emitted from neutrinospheres; predictions are: $\langle E\ \square_{\square},\square_{\square}\rangle$ =20-30 MeV ; $\langle E\ \square_{e}\rangle$ = 8-13 MeV

- Detect short-time phenomena; possible collapse to a black hole.

- Examine late-time effects; cooling of the neutron star
  - Neutrino energy distributions beyond the first few seconds

# OMNIS Neutrino Physics

- Direct Neutrino Mass Measurements: all neutrino species
  - ~10-20 eV/$c^2$
  - Especially powerful if SN core collapses to a Black Hole (sharp time cutoff) ~ 3 eV/$c^2$

- Neutrino Oscillations: Measure the energy spectra
  - MSW transitions outside of the core are expected to produce hot $\nu_e$ and cooler $\nu_\mu$ ,$\nu_\tau$
  - This depends on $\theta_{13}$ and if MSW transitions happen in the C/He or He/H shells

# Two Types of Detectors for OMNIS

- 2 kT: Lead Slabs & (Scintillators + Gd Sheets)
  - Four 1/2 kT Modules
  - Detect neutrons produced from $\nu$ – Pb cc & nc interactions
  - Number of neutrino events from 8kpc Supernova: ~1,500

- 1 kT: Lead Perchlorate Dissolved in Water
  - Twenty 50-Ton modules
  - Detect neutrons produced from $\nu$ – Pb cc & nc interactions

    *AND* electrons produced from $\nu_e$ – Pb cc interactions
  - Measure the Energy spectrum of $\nu_e$ events
  - Number of neutrino events from 8kpc Supernova: ~ 700

# OMNIS Lead-Scintillator Detector

- Detection Method: $\nu$ + Pb → X + (1 or 2 neutrons)
  - “prompt signal” ~1 MeV neutron excites scintillator
  - “delayed signal” ~30μs later, thermalized n captures on Gd
  - Obtain a rough energy spectrum of neutrinos from rate of single neutron to double neutron events
  - *Note: cc and nc signals are indistinguishable*
  - Why Lead?
    - Large neutrino cross section and low threshold (7.4 MeV for single neutron nc events)
    - High neutron production efficiency
    - Low neutron absorption

# OMNIS Lead Perchlorate Detector

A Transparent Lead Perchlorate-Water Solution

(Soluble up to 80% by weight)

- Detection Method: $\nu_e$ + Pb → $e^-$ + X + (1 or 2 neutrons)
  - "prompt signal" $e^-$ Cerenkov ring
  - "delayed signal" 10-100$\mu$s later, thermalized n captures on Cl
- **Determine nc/cc ratio**
- **Measure $\nu_e$ energy spectrum**
  - The $\nu_e$ represent the $\nu_\mu$ ,$\nu_\tau$ energy spectra before MSW transitions!

# OMNIS Conclusion

There is much to learn from a Galactic Supernova

- Dynamics of SN processes
- Cooling of neutron star
- Collapse to a black hole
- Neutrino mass limits
- Neutrino oscillations

- OMNIS will be a supernova neutrino observatory designed to operate for ~50 years, with unique capabilities that are complementary to existing facilities.